A Portable 3D Body Scanner

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Abstract

A portable 3D scanner for a whole human body measurement is described in this paper. This body scanner is light and ultra-compact. It is able to scan a whole human body shape in only 2 seconds. Measurements can be made up to 1 million points and more so that the average margin of error is 3 mm or less. The body scanner consists of three pole units. Each pole unit weights 12.1 kg, light enough to be carried by one person. The pole units are assembled by just fitting the unit into the pedestal and fastening it in with a wrench. Through original, advanced calibration technology, determining the placement of the three pole units is finish within 15 minutes.

Keywords: 3D Body Scanner, Portable, High-Speed, Smart Calibration

1. Introduction

The scanning method which makes a light source and a camera move mechanically is popular for a whole human body scanning until now [1-3]. This type of body scanner scans between a head and feet of a subject sequentially, and then stacks up sectional profiles in order to obtain a whole body shape. Because of this mechanism which makes a light source and a camera move mechanically, the size and the weight tends to be large and heavy. At the time of an installation of the body scanner technical staffs need to be called into mechanical adjustment for several days. Furthermore, owing to this mechanism, generally it takes more than 5 seconds to scan a whole body shape. Because swaying of a human body becomes larger and larger during standing upright, the measurement time is an important factor for a whole body scanning. Therefore, it is better to scan as quickly as possible.

By the way, a new type of body scanner, which projects a lighting pattern in order to obtain a whole body shape, was released in recent years [4-6]. Space-encoding method or Phase-shift method is used for the measuring principle. Generally speaking, because this type of the body scanner is able to switch patterns quickly, the measurement time is shorter than the body scanner which uses light-section method. In addition, a measurement module becomes light and compact owing to mechanical simple construction. However, multiple measurement modules are used for a whole body scanning, and a technical hurdle of multiple measurement modules system is high. Especially, a part which becomes occlusion easily, such as an armpit or a crotch, is difficult for the body scanner with two viewpoints or four viewpoints to measure. In addition, because 3D point cloud measured by each measurement module is described by individual camera coordinate system, the geometric relations of each camera coordinate systems need to be determined accurately for this body scanner. Thus, the calibration work which determines the relation among multiple measurement modules is required at an installation of the body scanner. The accuracy of the body scanner depends on the accuracy of the calibration method. The strict and accurate calibration needs a technical staff and special rigs. So it is difficult to carry the body scanner until now even if it is light and compact.

We introduce Portable 3D Body Scanner as shown in Fig. 1 in this paper. Three pole units which have light and ultra-compact measurement modules called “3D Camera” compose this body scanner. A subject stands at the center of three pole units during 3D scanning, and then a whole body shape of the subject is scanned in only 2 seconds. Each pole unit weights 12.1 kg and pedestal weights 14.6 kg, light enough to be carried by one person. The pole units are assembled by just fitting the unit into the pedestal and fastening it in with a wrench. A calibration after an installation is finish within 15 minutes. In this paper, the components of the body scanner, a calibration work, measurement results and application software are described.

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Fig. 1. Cartesia Series Portable 3D Body Scanner

2. Portable 3D Body Scanner

2.1 3D Scanning

Cartesia Series Portable 3D Body Scanner is able to acquire a whole body shape in only 2 seconds. Table 1 shows the specifications of Portable 3D Body Scanner. The scanner consists of three pole units. Three measurement modules which called “3D Camera” are installed in each pole unit (Fig. 2). In total, nine 3D cameras are used for acquiring a human body shape. The nine cameras are arranged at the optimal viewpoints and angles for photographing the human body, resulting in minimal occluding parts. 3D camera obtains an accurate shape of a subject in 0.5 seconds. In case of a whole body scanning it takes 4 times to scan using nine cameras simultaneously, so the measuring time is just 2 seconds in total. Although a trunk swaying increases when a human stand upright, it is possible to scan a whole human body shape without swaying by high-speed measurement.

Each pole unit weights 12.1 kg, light enough to be carried by one person. The pedestal which supports the pole unit weights 14.6 kg. The pole units are assembled by just fitting the unit into the pedestal and fastening it in with a wrench. The body scanner does not have mechanism which makes a light source and a camera move vertically. This simple construction realizes easy assembly and avoids problems with operation. Also, this body scanner is able to scan without making noise or vibrating. The subject being photographed will feel no discomfort.

3D Camera switches laser slit ray speedy in order to project gray code patterns [7, 8] and a surface shape of a subject is measured based on space-encoding method. If a scan data is required to be more high-accuracy and high-resolution, the hybrid-method which combines space-encoding method with phase-shift method is also available [9]. Although a semiconductor red-color laser is utilized for the light source, the light is not harmful to human eyes thanks to Class 1(IEC 60825-1 Safety of laser products). Also, this body scanner does not use a light source which consumes large amounts of energy, such as a halogen lamp.

Table 1. Portable 3D Body Scanner Specifications

Pole-Unit Specifications	
Dimensions	W400 x D400 x H1910 mm
Weight	Pole Unit: 12.1 kg Stand: 14.6kg
Portable 3D Body Scanner Specifications	
Setup Area	W1980 x D2190 x H1910 mm
Measurement Accuracy	RMSE 3.0 mm or less
Resolution	x/y 1.4 mm
Imaging Time	2.0 seconds
Interface	USB2.0, IEEE1394a
Power Supply Requirements	AC100-240V 50/60Hz
Energy Consumption	60W

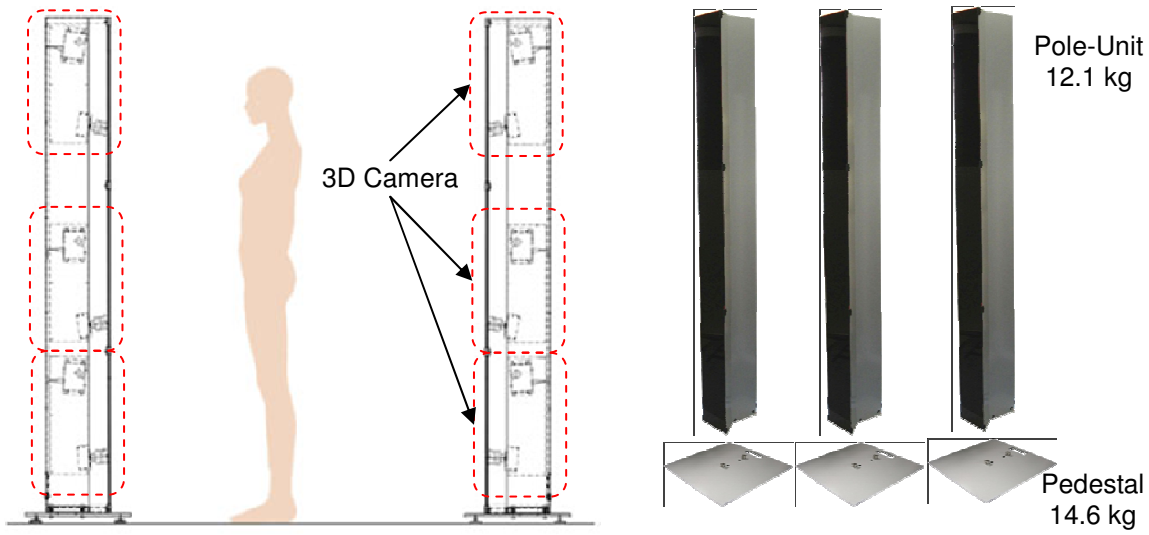


Fig. 2. Components of Portable 3D Body Scanner

2.2 System Setup and Calibration

The one of the advantage points of the body scanner is portability. At the installation three pedestals are located in setup area (wide 2 m, depth 2.2 m). The pole units are assembled by just fitting the unit into the pedestal and fastening it in with a wrench. At this time the position and the direction of pole unit does not have to be adjusted strictly. A geometric relation among the pole units, such as the position and the direction, is automatically determined by our calibration method.

In case of scanning a complex and rugged object, such as a human body, two approaches are available; the approach which move a light source and a camera vertically or the approach which scan a whole body using multiple cameras. In case of the former, because of the mechanism which moves or shifts the light source and the camera, it need to be adjusted strictly and maintained periodically. In case of the latter, although the mechanical structure is not used, multiple cameras for scanning a whole human body are required. From a point of view of Computer Vision, increasing of the number of the cameras makes the calibration problem more difficult. The geometric relation of the nine cameras as shown in Fig. 3 needs to be determined accurately for this body scanner. Put another way, the transformation between the world coordinate system and the camera coordinate system of each camera needs to be estimated accurately. This problem for the body scanner is solved by our advanced calibration technology [10-12].

We will focus our attention on calibration work of this body scanner. A calibration panel as shown in Fig. 4(a) is used for the calibration work. First, an operator hangs the calibration panel on a calibration rig (see Fig. 4 (b)). Second, the operator adjusts the height of calibration panel according to calibration software. The calibration software scans the calibration panel and calculates parameters automatically. Technical knowledge of this calibration works is not required for the operator. Anybody is able to finish the calibration work within 15 minutes and the body scanner becomes ready.

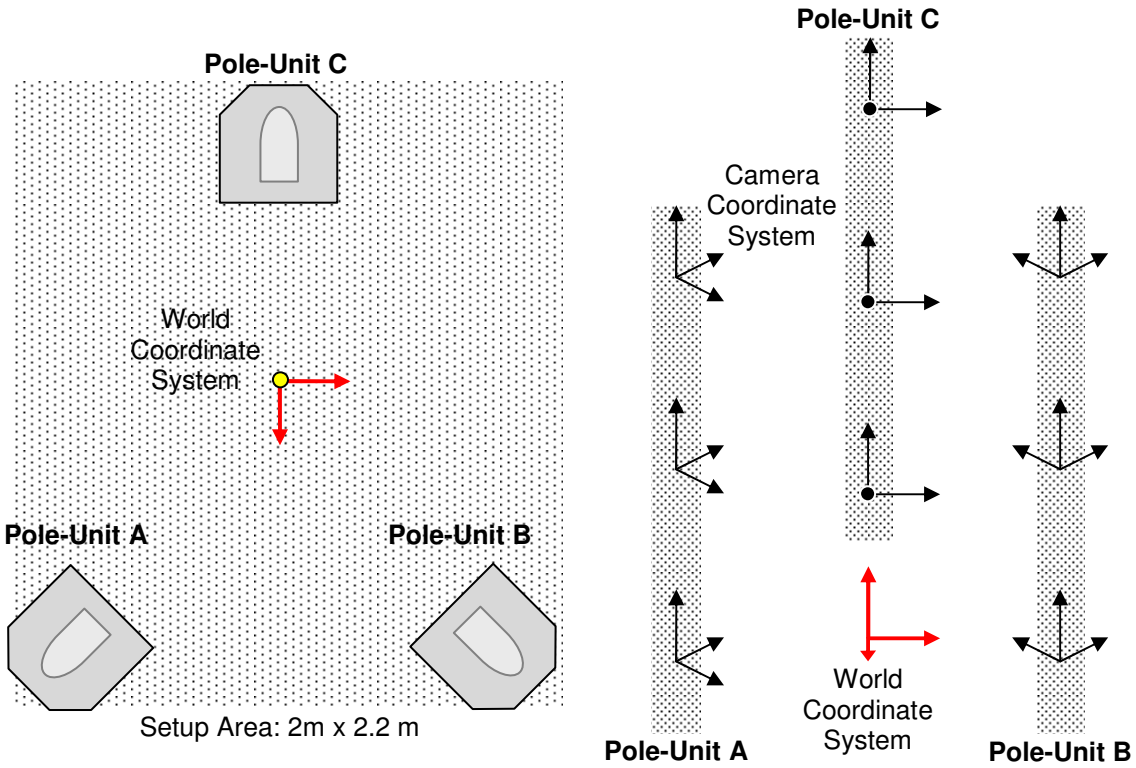
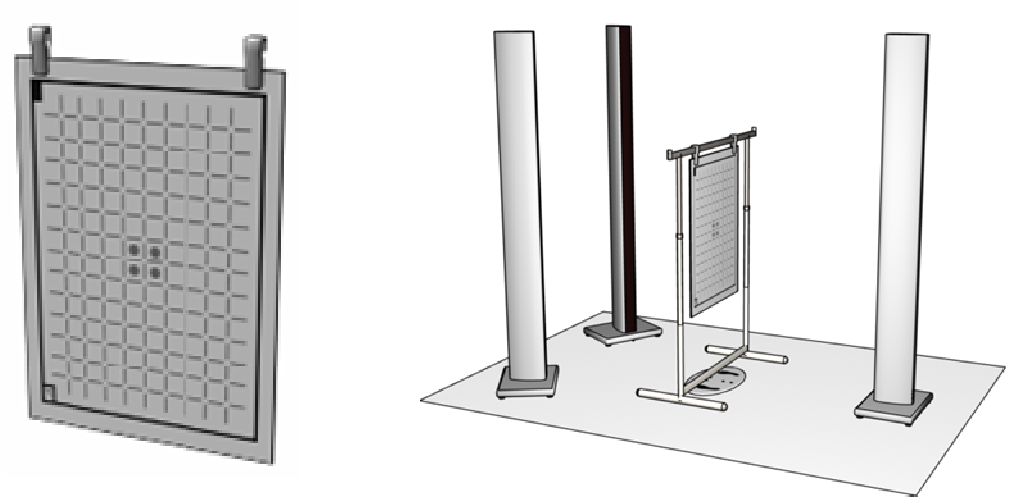


Fig. 3. Calibration for 3D Body Scanner

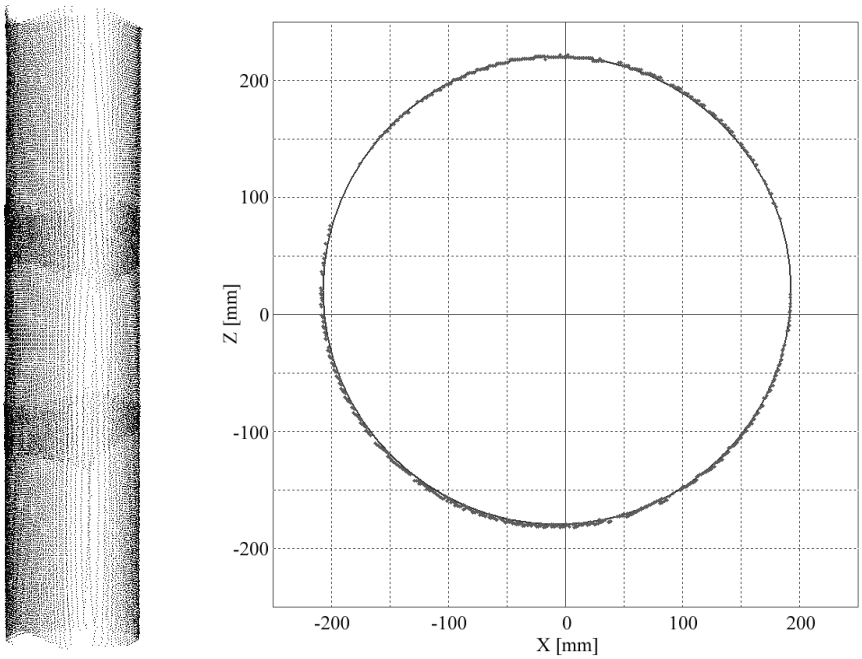


(a) Calibration panel *(b) Setup of a calibration panel*

Fig. 4. Overviews of Calibration

2.3 Measurement result

A measurement result of a cylinder object with 200 mm diameter and 2000 mm height is shown in Fig. 5. Fig. 5 (b) is a horizontal slice of the cylinder object at 800 mm height. In this case, RMSE of a circle fitting error is found to be 3 mm. A measurement sample of a Japanese female is shown in Fig. 6.



(a) Scanned points *(b) Horizontal Slice (Height: 800mm)*

Fig. 5. Scan result of a cylinder object

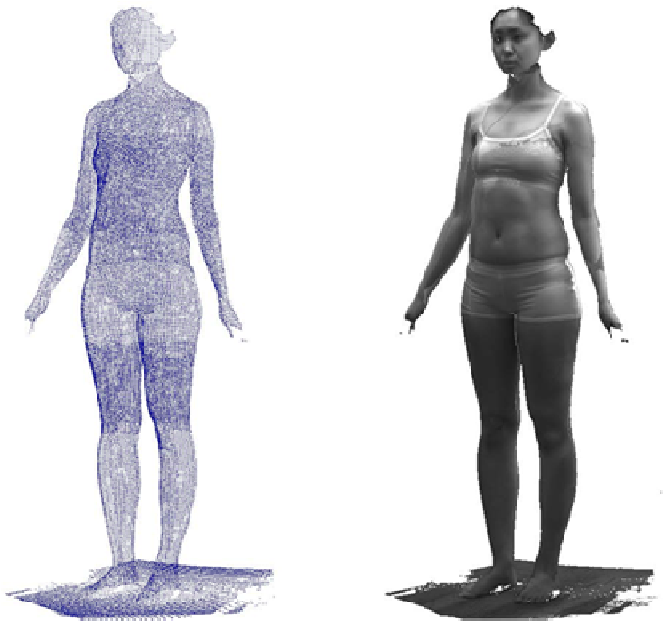


Fig. 6. Scan result of a female

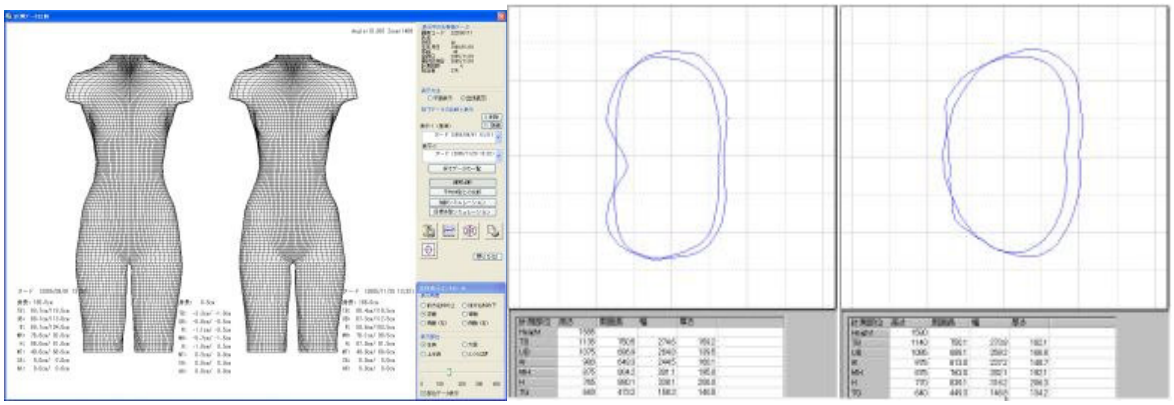


Fig. 7. Screen images of Cousette (Hokuriku STR Cooperative)

3. Application

Portable 3D Body Scanner is expected to be used in the field of apparel, beauty, health and medical. This body scanner is used by Cousette [13] as shown in Fig. 7. Cousette is software for evaluation and simulation of aging and wearing of women's underwear using. This software is able to obtain circumferences, such as a bust, a waist and hip automatically and compare a measured body shape with an average body shape or a body shape measured previously. In addition, 3D Navi [14], a body shape simulation service, will use this body scanner.

4. Conclusion

Portable 3D Body Scanner is described in this paper. It is compact, lightweight and able to scan a whole human body in only 2 seconds. The body scanner consists of three pole units. Each pole unit weights 12.1 kg and pedestal weights 14.6 kg, light enough to be carried by one person. The pole units are assembled by just fitting the unit into the pedestal and fastening it in with a wrench. A calibration after an installation is finish within 15 minutes. Because a whole body scanning becomes easier using the body scanner, it is expected to be used by various applications.

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